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#4
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EVALUATION OF A COMMERCIAL GEOGRAPHIC DATA BASE FOR STORAGE AND RETRIEVAL OF FOREST INSECT AND DISEASE INFORMATION

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DISCLAIMER STATEMENT

Report 79-4

3400
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EVALUATION OF A COMMERCIAL GEOGRAPHIC DATA BASE SYSTEM FOR STORAGE AND RETRIEVAL OF FOREST INSECT AND DISEASE INFORMATION

100 Robert W. Young[1]

ABSTRACT

A geographic data base system was evaluated for storage and retrieval of forest insect data on the Black Hills and Targhee National Forests. The initial demonstration project has captured data on land ownership boundaries, ecological land units, and mountain pine beetle infestation areas. Both acreage summaries and computer-generated maps were produced. The project utilized an operational state of the art system from a commercial vendor.

INTRODUCTION

Geographic data base systems (computerized mapping) are a potential tool for inputting, storing, retrieving, analyzing, and reporting resource information in a timely and efficient manner. The Forest Insect and Disease Management Methods Application Group (FI&DM/MAG) has been investigating capabilities of geographic data base systems for analysis, storage, and display of forest insect and disease data (Young 1977).

A geographic data base system tied to a forest insect and disease reporting system can:

-Summarize data at the Forest, Regional, or National planning level.

-Provide for data comparability between Regions and Areas.

-Be compatible with other resource data elements (e.g., soil types, vegetation, access, land-use classification, etc.).

-Provide for reporting of insect and disease status and program accomplishments.

-Provide graphic and tabular outputs.

This report documents results of a demonstration project utilizing an operational state-of-the-art commercial vendor's geographic data base system. Objectives of the demonstration were to evaluate an operational system for analysis, storage, and retrieval of information on the status of forest insects and diseases.

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METHODS

Study Areas

Two study areas, the Black Hills National Forest, South Dakota, and the Targhee National Forest, Idaho, were included in the demonstration. Both areas have a history of recent destructive outbreaks of the mountain pine beetle, *Dentroctonous ponderosae* Hopkins, and have served as pilot sites for estimating annual losses (Ciesla and Klein 1978, Klein *et al.* 1979).

Commercial Vendor

COMARC DESIGN SYSTEMS of San Francisco, California, was selected to provide the required services. At the time of project conception, the COMARC system, to the best of our knowledge, had the only operational system that met basic needs (See Appendix for specific details). General features of the COMARC's system consists of the following:

1. Human engineering. This is a term used to describe systems designed for primary users, not necessarily for computer specialists. COMARC's interactive program allows the user to process map data files easily, including editing files, generating a tabular summary, overlaying two map files, or calling for a plot to be drawn.

2. Allows for digitizing directly from source maps; inked mylar overlays are not necessary.

3. Accepts source maps in different scales.

4. Digitizes in arc polygon, point, or grid mode; when in arc polygon mode eliminates the double trace in map outputs and the "slivers" in acreage calculations.

Preparation of Data Base

Establishing an insect and disease geographic data base involves many processes. Major tasks in the demonstration project included (1) obtaining source maps; (2) digitizing and editing computer-generated files; (3) overlaying various map layers; (4) producing acreage summaries; and (5) plotting maps (Fig. 1). Specific details for each step follow.

Source Maps

Source maps utilized for the project consisted of:

Black Hills National Forest

Ownership
Ecological land unit
1977 aerial detection insect survey map

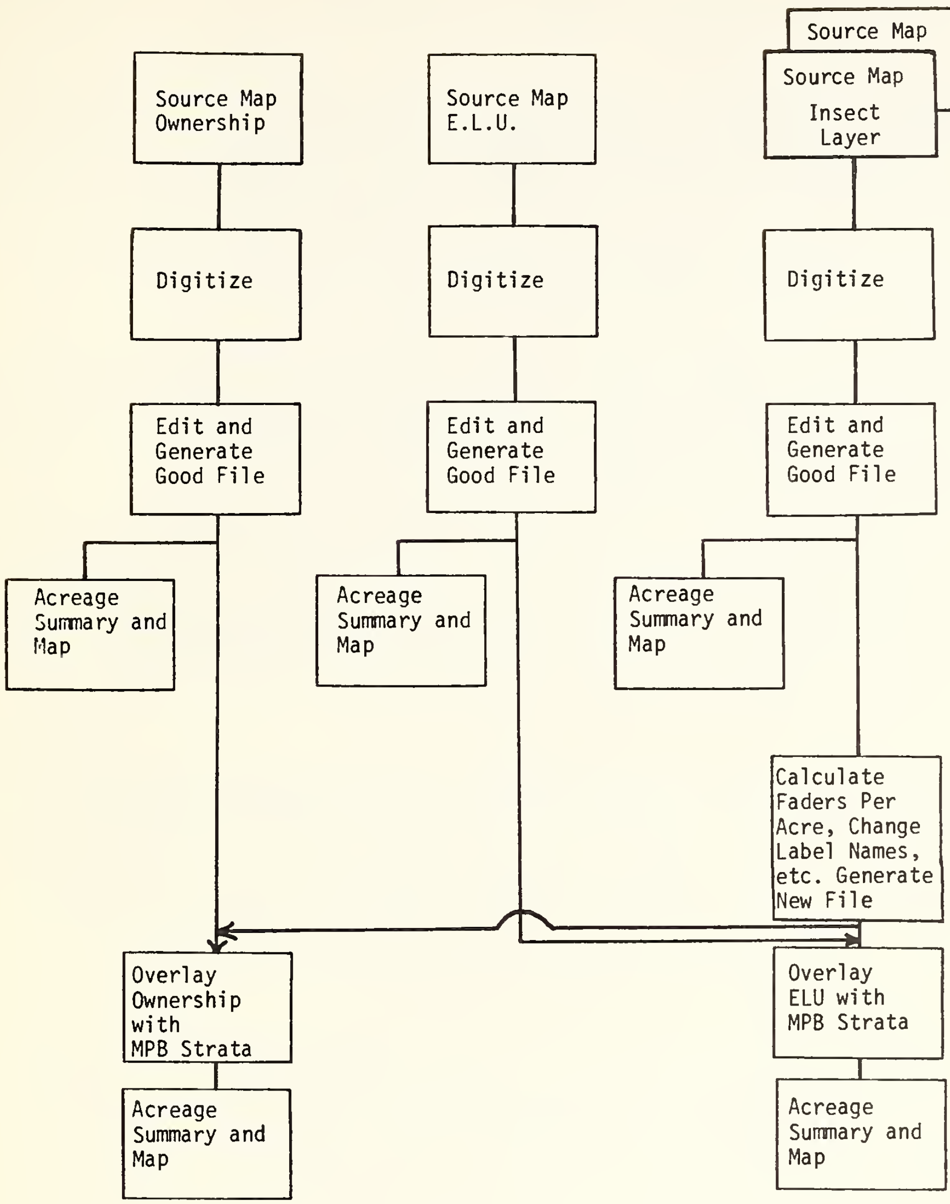

Figure 1. Generalized processing diagram depicting sequence of events for the demonstration project.

Targhee National Forest

Ownership
1976 aerial detection insect survey map
1977 aerial detection insect survey map

Ownership: Forest Service planimetric maps (½ inch = 1 mile) were used for the ownership layer. The color-coded maps depict ownership of: National Forest (1), private (2), Bureau of Land Management (3), State lands and parks (4), National Parks (5), and large bodies of water (98); the numbers in parentheses were used to identify polygon labels. For this particular project, small parcels of private land (< 160 acres) within Forest Service boundaries were not separated.

Ecological Land Units (ELU): The Black Hills National Forest is subdivided into management planning units designated as ecological land units (ELU). An ELU map (½ inch = 1 mile) depicting boundaries of each ELU was provided by the Forest. The ELU number was used for the polygon label (USDA Forest Service 1977).

Insect Information: The Black Hills National Forest aerial sketch map[2] was used for the insect layer. This map (½ inch = 1 mile) delineated approximate locations and intensities of 1977 faded trees (trees attacked and killed in 1976 by the mountain pine beetle), for the entire forested area. Estimated number of dead trees within each polygon was used for polygon labels.

Both the 1976 and 1977 Targhee National Forest aerial sketch map surveys were used for the insect layers. The insect maps included mountain pine beetle in lodgepole pine, Douglas-fir beetle, and western spruce budworm in Douglas-fir stands. Polygon labels were estimated number of dead trees for the bark beetles and defoliation intensities (light, moderate, or heavy) for the spruce budworm infestation areas.

Digitizing and Editing

Each source map was digitized using COMARC's arc polygon process. This technique eliminated digitizing common boundaries of two adjoining polygons twice, thereby eliminating the "double trace" on map outputs. Separate polygon files were created for each insect pest (mountain pine beetle, Douglas-fir beetle, and western spruce budworm).

Following digitizing, computer files were edited. Both computer edits and visual comparisons were made. The computer edit internally checked for missing line segments (ARC's) and for polygon closures. The

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[2] Sketch mapping is a technique used by forest entomologists for delineating areas of forest insect and disease infestations. The specialist flies over the forested areas and draws on a map relative locations and intensities of insect and disease infestations visible from the air.

visual edit was done by manually overlaying the computer-generated source map over the source map and then visually checking for accuracy and completeness.

Stratification Procedures

The bark beetle layers were stratified into three intensity classes. The original polygon labels for the bark beetle layers were an estimate of the number of dead trees associated with a specific polygon boundary. An external computer program (not part of COMARC's processing system) was written to do the following:

-Compute dead trees per acre for each polygon (Fig. 2).

-Sort polygons from smallest to largest based on dead trees per acre.

-Generate a listing of sorted files including polygon number, dead trees, acres, and accumulations of dead trees and acres (Fig. 3).

-Establish intensity boundaries from previous step's output (manual operation).

-Relabel each new polygon from the previous step by intensity class 1, 2, or 3 (computer operation).

Map Overlays

The following map overlays were generated from the edited and relabeled files:

Black Hills National Forest

1977 mountain pine beetle status over ownership.
Mountain pine beetle status over ELU.

Targhee National Forest

1976 mountain pine beetle status over ownership.
1977 mountain pine beetle status over ownership

The overlay process involved taking two polygon map computer files and processing them together using COMARC's polygon intersection technique. The outputs from this process included acreage summaries and computer-generated maps.

RESULTS

End products included acreage summaries, computer-generated maps, and a geographic data base. Tabular outputs included:

-Ownership, Black Hills National Forest (Tables 1 and 2).

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FILE NAME - F6MPBL08.P5

SEQ. NO.	LAB NO.	LABEL NAME	POLY. ACRES	POLY. DT/ACRE
1	16	MPBL 50 DT	171.09	.29
2	22	MPBL 100 DT	660.97	.15
3	16	MPBL 50 DT	205.01	.24
4	22	MPBL 100 DT	336.11	.30
5	22	MPBL 100 DT	398.49	.25
6	28	MPBL 200 DT	502.35	.40
7	22	MPBL 100 DT	323.08	.31
8	28	MPBL 200 DT	638.87	.31
9	16	MPBL 50 DT	199.58	.25
10	22	MPBL 100 DT	334.92	.30
11	31	MPBL 300 DT	364.23	.82
.				
.				
.				
229	43	MPBL 1000 DT	995.47	1.00
230	22	MPBL 100 DT	345.24	.29
231	28	MPBL 200 DT	1185.91	.17
232	22	MPBL 100 DT	391.57	.26
233	22	MPBL 100 DT	705.18	.14
234	22	MPBL 100 DT	309.24	.32
235	34	MPBL 400 DT	867.71	.46
236	22	MPBL 100 DT	479.67	.21

Figure 2. Example of output computing polygon dead trees per acre.

INSECT DISEASE REPORT PAGE 1

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FILE NAME - F6MPBL08.P5

SEQ. NO.	LAB NO.	LABEL NAME	POLY. ACRES	ACCUM. D/TREES	ACCUM. ACRES	POLY. DT/ACRE
39	22	MPBL 100 DT	1808.06	100.	1808.06	.06
154	7	MPBL 20 DT	222.75	120.	2030.81	.09
149	16	MPBL 50 DT	510.52	170.	2541.33	.10
115	16	MPBL 50 DT	482.31	220.	3023.64	.10
32	22	MPBL 100 DT	948.09	320.	3971.73	.11
24	13	MPBL 30 DT	240.37	350.	4212.10	.12
197	28	MPBL 200 DT	1621.99	550.	5834.09	.12
37	16	MPBL 50 DT	405.68	600.	6239.77	.12
215	16	MPBL 50 DT	418.41	650.	6658.17	.12
25	16	MPBL 50 DT	417.50	700.	7075.67	.12
191	22	MPBL 100 DT	750.56	800.	7826.23	.13
192	16	MPBL 50 DT	393.41	850.	8219.64	.13
183	19	MPBL 75 DT	538.19	925.	8757.82	.14
233	22	MPBL 100 DT	705.18	1025.	9463.00	.14
.						
.						
.						
193	43	MPBL 1000 DT	246.87	243245.	236688.10	4.05
201	58	MPBL 5000 DT	1229.39	248245.	237917.40	4.07
164	67	MPBL10000 DT	2103.69	258245.	240021.10	4.75
213	58	MPBL 5000 DT	1045.15	263245.	241066.20	4.78
91	64	MPBL 8000 DT	1422.85	271245.	242489.10	5.62
168	70	MPBL15000 DT	2539.97	286245.	245029.00	5.91

Figure 3. Example of output following sorting polygon file and accumulating dead trees and acres.

-Mountain pine beetle infestation area by intensity class, Black Hills National Forest, 1977 (Tables 3 and 4).

-Mountain pine beetle infestation area by ownership, Black Hills National Forest, 1977 (Table 5).

-Ownership, Targhee National Forest (Tables 6 and 7).

-Insect infestation areas, Targhee National Forest, 1976-77 (Tables 8, 9, and 10).

-Insect infestation areas by ownership, Targhee National Forest 1976-77 (Tables 11, 12, 13).

Additional tabular outputs included acreage summaries for each ecological land unit for the Black Hills National Forest and the acreage infested by mountain pine beetle within each ELU.

The acreage estimates shown on the tables came directly from COMARC's acreage report generator. Reporting of the acreage estimates to the nearest acre does not imply accuracy at that level. Recall that the data source for the insect information was collected by aerial sketch mapping. This is a subjective procedure for delineating insect and disease infestation areas. Insect acreage estimates along with map outputs provide relative information on location and intensity of major problem areas.

Computer-generated map outputs include:

-Black Hills National Forest land ownership (Fig. 4).

-Black Hills National Forest ecological land units (Fig. 5).

-Black Hills National Forest 1977 mountain pine beetle status (Fig. 6).

-Black Hills National Forest 1977 mountain pine beetle map over ELU (Fig. 7).

-Targhee National Forest land ownership map (Fig. 8).

-Targhee National Forest 1976 mountain pine beetle status (Fig. 9).

-Targhee National Forest 1977 mountain pine beetle status (Fig. 10).

-Targhee National Forest 1977 mountain pine beetle map over ownership (Fig. 11).

Table 1. Ownership layer, Black Hills National Forest, South Dakota.

Ownership Class	Polygon Label	Computed Acres
National Forest	(1)	1,352,891
Private	(2)	610,296
BLM	(3)	28,303
State Land and Parks	(4)	102,888
National Parks	(5)	30,931
Water	(98)	4,809
Total		2,130,118

Table 2. Computer-generated output of ownership layer, Black Hills National Forest, South Dakota.

```
***********************************************************************
*        P O L Y G O N   L A B E L   R E P O R T          PAGE  1    *
*                                                                     *
*        COMARC DESIGN SYSTEMS - SAN FRANCISCO             9  1 1978  *
***********************************************************************
* CLIENT NO. = 2127      FILE NAME = BHOWN.P6        XMIN  = 655829  *
* PROJECT NO.=    2      DATA TYPE    = OWNERS       XMAX  =1216887  *
* MAP TYPE   =    1      # OF LABELS  =       8      YMIN  = 359784  *
* MAP NO.    =  .01      # OF POLYGONS=     535      YMAX  = 923497  *
* FILE TYPE  =   35      TOTAL ACRES  =2130012       SCALE = 126720  *
***********************************************************************
*  LAB      LABEL        TOTAL      # OF          PERCENT OF          *
*  NUM      NAME         ACRES      POLYS        ACRES    POLYS       *
*                                                                     *
*    1  NAT. FOREST   1352891.00     197          63.52    36.62      *
*    2  PRIVATE        610296.40     116          28.65    21.68      *
*    3  B.L.M.          28302.82     104           1.33    19.44      *
*    4  STATE LAND     102888.00      97           4.83    18.13      *
*    5  NAT. PARK       30930.49       5           1.45      .93      *
*   98  WATER            4809.45      16            .23     2.99      *
*                                                                     *
*          535 POLYGONS ON MAP TOTALING TO 2130012.000 ACRES          *
***********************************************************************
```

Table 3. Mountain pine beetle infestation by intensity class, Black Hills National Forest, South Dakota, 1977.

Intensity Class (faders/acre)	Polygon Label	Estimated Acres
0.1 - 1.99	(1)	497,290
2.0 - 3.99	(2)	16,099
4+	(3)	8,622
Total		522,011

Table 4. Computer-generated output of mountain pine beetle infestation, Black Hills National Forest, South Dakota, 1977.

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**********************************************************************
*          P O L Y G O N   L A B E L   R E P O R T          PAGE  1 *
*                                                                    *
*          COMARC DESIGN SYSTEMS - SAN FRANCISCO           9  1 1978 *
**********************************************************************
* CLIENT NO. = 2127        FILE NAME = BHINOB.IC       XMIN  = 876892 *
* PROJECT NO.=    2        DATA TYPE    = INSECT       XMAX  =1194385 *
* MAP TYPE   =    1        # OF LABELS   =      4      YMIN  = 522886 *
* MAP NO.    =  .01        # OF POLYGONS=   1092       YMAX  = 836343 *
* FILE TYPE  =   81        TOTAL ACRES   = 522008      SCALE = 126720 *
**********************************************************************
*  LAB     LABEL         TOTAL      # OF        PERCENT OF            *
*  NUM     NAME          ACRES      POLYS      ACRES    POLYS         *
*                                                                     *
*    1  INTENSITY 1    497290.30    1011        95.26    92.58        *
*    2  INTENSITY 2     16098.68      54         3.08     4.95        *
*    3  INTENSITY 3      8621.80      27         1.65     2.47        *
*                                                                     *
*        1092 POLYGONS ON MAP TOTALING TO  522008.200 ACRES           *
**********************************************************************
```

Table 5. Mountain pine beetle infestation area by ownership, Black Hills National Forest, South Dakota, 1977.

Ownership Class	Acreage Estimates Intensity Classes 0.1 - 1.99	2.0 - 3.99	4+	Total
National Forest	423,082	14,152	5,934	443,168
Private	37,945	1,522	1,193	40,660
BLM	3,435	358	507	4,300
State Lands	6,451	--	306	6,811
National Parks	632	--	--	632
Water	165	--	--	165
Total	471,710	16,032	7,994	495,736

Table 6. Ownership layer, Targhee National Forest, Idaho.

Ownership Class	Polygon Label	Computed Acres
National Forest	(1)	1,170,767
Private	(2)	117,178
National Parks	(5)	138,515
Water	(98)	31,462
Total		1,457,922

Table 7. Computer-generated output of ownership layer, Targhee National Forest.

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**************************************************************************
*          P O L Y G O N   L A B E L   R E P O R T             PAGE  1   *
*                                                                        *
*          COMARC DESIGN SYSTEMS - SAN FRANCISCO              7 24 1976  *
**************************************************************************
* CLIENT NO. = 2127        FILE NAME = FSOWN2.PS        XMIN  = 606441   *
* PROJECT NO.=    1        DATA TYPE    = OWNSHP        XMAX  = 671645   *
* MAP TYPE   =    1        # OF LABELS  =       4       YMIN  = 534496   *
* MAP NO.    =  .01        # OF POLYGONS=     119       YMAX  =1126516   *
* FILE TYPE  =   35        TOTAL ACRES  =1457891        SCALE = 250000   *
**************************************************************************
*  LAB       LABEL         TOTAL       # OF           PERCENT OF         *
*  NUM       NAME          ACRES       POLYS        ACRES    POLYS       *
*                                                                        *
*    1  NAT. FOREST   1170767.00        21          80.31    17.65       *
*    2  PRIVATE        117177.70        63           6.04    69.75       *
*    5  NAT. PARK      138514.70         1           9.50      .84       *
*   98  WATER           31461.99        14           2.16    11.76       *
*                                                                        *
*          119 POLYGONS ON MAP TOTALING TO 1457891.000 ACRES             *
**************************************************************************
```

Table 8. Acres infested, by host type, insect, and intensity class, Targhee National Forest, 1977.

Host/Insect/Intensity	1976 Computed Acres	1977 Computed Acres
Lodgepole Pine		
Mountain pine beetle		
0.1 - 2.99 trees/acre	199,887	246,614
2.0 - 3.99 trees/acre	36,554	79,352
4+ trees/acre	8,588	34,907
Total	245,029	360,873
Douglas-fir		
Douglas-fir beetle		
0.1 - 1.99 trees/acre	6,093	2,992
2.0 - 3.99 trees/acre	62	73
4+ trees/acre	--	--
Total	6,155	3,065
Spruce budworm		
light defoliation	7,291	2,779
medium defoliation	5,980	--
heavy defoliation	3,503	--
Total	26,774	2,779

Table 9. Computer-generated output of mountain pine beetle status by intensity class, Targhee National Forest, Idaho, 1976.

```
*******************************************************************************
*         P O L Y G O N   L A B E L   R E P O R T               PAGE  1  *
*                                                                         *
*         COMARC DESIGN SYSTEMS - SAN FRANCISCO              9  5 1978  *
*******************************************************************************
* CLIENT NO. = 2127       FILE NAME = F6MPBLOW.IC      XMIN  = 617466 *
* PROJECT NO.=     1      DATA TYPE     = BEETLE       XMAX  = 850921 *
* MAP TYPE    =    1      # OF LABELS  =        4      YMIN  = 552912 *
* MAP NO.     =  .01      # OF POLYGONS=      230      YMAX  =1108730 *
* FILE TYPE   =   81      TOTAL ACRES  = 245027        SCALE = 126720 *
*******************************************************************************
*  LAB        LABEL        TOTAL       # OF          PERCENT OF              *
*  NUM        NAME         ACRES       POLYS         ACRES    POLYS          *
*                                                                         *
*    1  INTENSITY 1     199887.10      199           81.58    86.52          *
*    2  INTENSITY 2      36553.89       25           14.92    10.87          *
*    3  INTENSITY 3       8587.91        6            3.50     2.61          *
*                                                                         *
*          230 POLYGONS ON MAP TOTALING TO  245027.900 ACRES              *
*******************************************************************************
```

Table 10. Computer-generated output of mountain pine beetle status by intensity class, Targhee National Forest, Idaho, 1977.

```
*******************************************************************************
*         P O L Y G O N   L A B E L   R E P O R T               PAGE  1  *
*                                                                         *
*         COMARC DESIGN SYSTEMS - SAN FRANCISCO              9  5 1978  *
*******************************************************************************
* CLIENT NO. = 2127       FILE NAME = F7MPBLOW.IC      XMIN  = 621104 *
* PROJECT NO.=     1      DATA TYPE     = MPBL         XMAX  = 857017 *
* MAP TYPE    =    1      # OF LABELS  =        4      YMIN  = 554159 *
* MAP NO.     =  .01      # OF POLYGONS=      220      YMAX  =1110065 *
* FILE TYPE   =   81      TOTAL ACRES  = 360871        SCALE = 250000 *
*******************************************************************************
*  LAB        LABEL        TOTAL       # OF          PERCENT OF              *
*  NUM        NAME         ACRES       POLYS         ACRES    POLYS          *
*                                                                         *
*    1  INTENSITY 1     246613.80      163           68.34    74.09          *
*    2  INTENSITY 2      79352.19       42           21.99    19.09          *
*    3  INTENSITY 3      34907.04       15            9.67     6.82          *
*                                                                         *
*          220 POLYGONS ON MAP TOTALING TO  360871.800 ACRES              *
*******************************************************************************
```

Table 11. Mountain pine beetle infestation by ownership class, Targhee National Forest, Idaho, 1976, 1977.

Year/Ownership Class	Intensity Class 0.1 - 1.99	2.0 - 3.99	4+	Total
1976				
National Forest	183,118	29,661	7,643	220,422
Private	16,342	6,552	930	23,824
National Park	--	--	--	--
Water	220	341	15	576
Total	199,680	36,554	8,588	244,822
1977				
National Forest	230,212	70,017	33,484	333,713
Private	11,661	7,888	4,191	23,740
National Park	--	--	--	--
Water	242	129	42	413
Total	242,115	78,034	37,717	357,866

Table 12. Computer-generated output of mountain pine beetle infestation status by ownership class, Targhee National Forest, Idaho, 1976.

P O L Y G O N   L A B E L   R E P O R T — PAGE 1

COMARC DESIGN SYSTEMS - SAN FRANCISCO — 7 21 1978

CLIENT NO. = 2127	FILE NAME = F6MPBL00.P8	XMIN = 617466
PROJECT NO.= 1	DATA TYPE = OWNSHP	XMAX = 850921
MAP TYPE = 1	# OF LABELS = 8	YMIN = 552912
MAP NO. = .01	# OF POLYGONS= 481	YMAX =1108730
FILE TYPE = 82	TOTAL ACRES = 244813	SCALE = 250000

LAB NUM	LABEL NAME	LAB NUM	LABEL NAME	TOTAL ACRES	# OF POLYS	PERCENT OF ACRES	PERCENT OF POLYS
1	NAT. FOREST	1	INT. CLASS 1	183117.50	230	74.80	47.82
1	NAT. FOREST	2	INT. CLASS 2	29661.36	44	12.12	9.15
1	NAT. FOREST	3	INT. CLASS 3	7642.59	11	3.12	2.29
2	PRIVATE	1	INT. CLASS 1	16341.61	111	6.68	23.08
2	PRIVATE	2	INT. CLASS 2	6551.66	41	2.68	8.52
2	PRIVATE	3	INT. CLASS 3	930.18	11	.38	2.29
98	WATER	1	INT. CLASS 1	219.86	8	.09	1.66
98	WATER	2	INT. CLASS 2	340.84	22	.14	4.57
98	WATER	3	INT. CLASS 3	15.11	3	.01	.62

481 POLYGONS ON MAP TOTALING TO 244813.200ACRES

Table 13. Computer-generated output of mountain pine beetle infestation status by ownership class, Targhee National Forest, Idaho, 1977.

P O L Y G O N   L A B E L   R E P O R T — PAGE 1

COMARC DESIGN SYSTEMS - SAN FRANCISCO — 7 21 1978

CLIENT NO. = 2127	FILE NAME = F7MPBL00B.P8	XMIN = 621104
PROJECT NO.= 1	DATA TYPE = OWNSHP	XMAX = 857017
MAP TYPE = 1	# OF LABELS = 12	YMIN = 554159
MAP NO. = .01	# OF POLYGONS= 471	YMAX =1110065
FILE TYPE = 82	TOTAL ACRES = 357855	SCALE = 250000

LAB NUM	LABEL NAME	LAB NUM	LABEL NAME	TOTAL ACRES	# OF POLYS	PERCENT OF ACRES	PERCENT OF POLYS
1	NAT. FOREST	1	INT. CLASS 1	230211.60	189	64.33	40.13
1	NAT. FOREST	2	INT. CLASS 2	70016.56	56	19.57	11.89
1	NAT. FOREST	3	INT. CLASS 3	33484.14	29	9.36	6.16
2	PRIVATE	1	INT. CLASS 1	11660.61	89	3.26	18.90
2	PRIVATE	2	INT. CLASS 2	7887.65	49	2.20	10.40
2	PRIVATE	3	INT. CLASS 3	4191.14	31	1.17	6.58
98	WATER	1	INT. CLASS 1	241.60	11	.07	2.34
98	WATER	2	INT. CLASS 2	128.99	14	.04	2.97
98	WATER	3	INT. CLASS 3	41.57	3	.01	.64

471 POLYGONS ON MAP TOTALING TO 357855.900ACRES

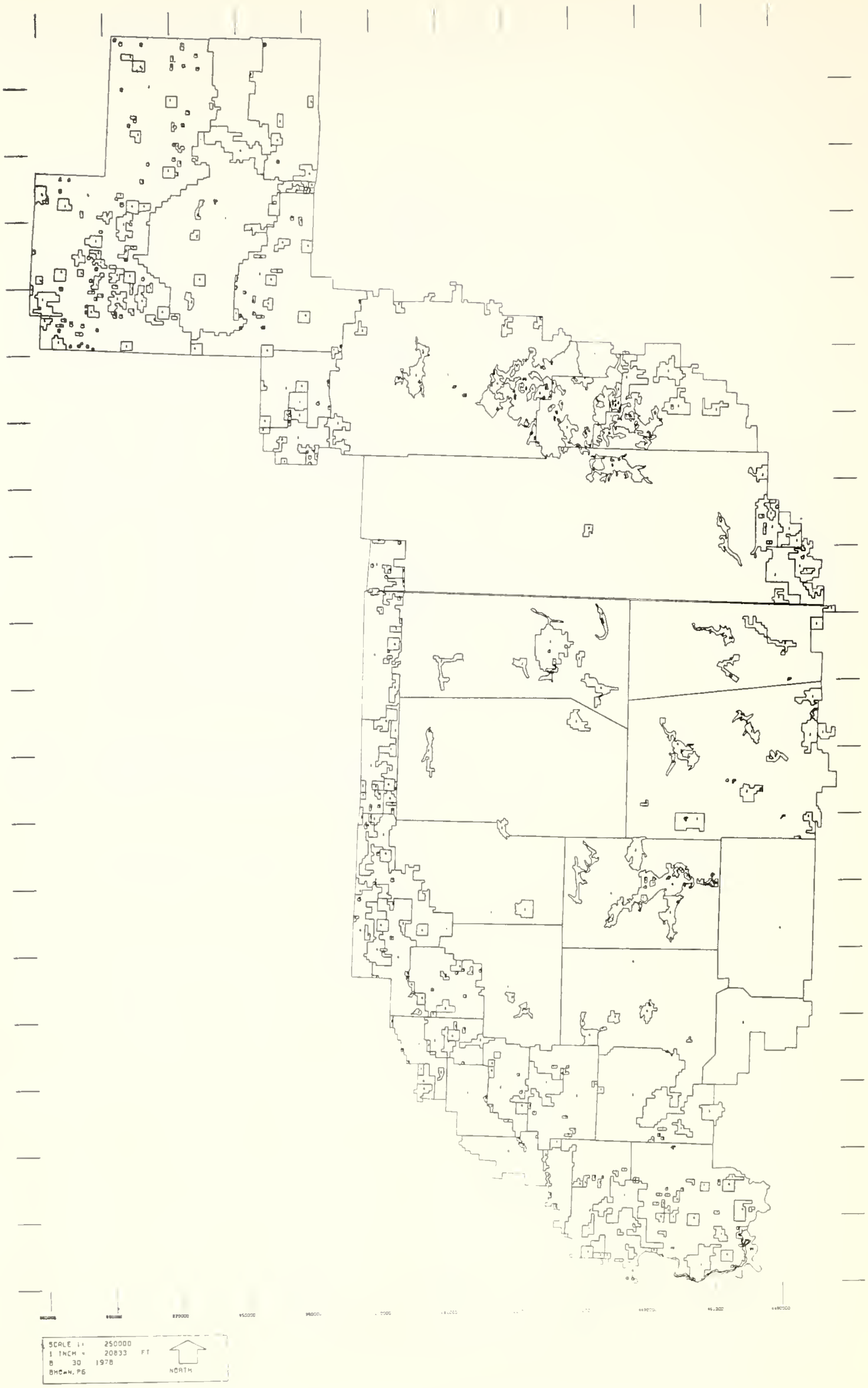

Figure 4. Ownership class map of the Black Hills National Forest, South Dakota

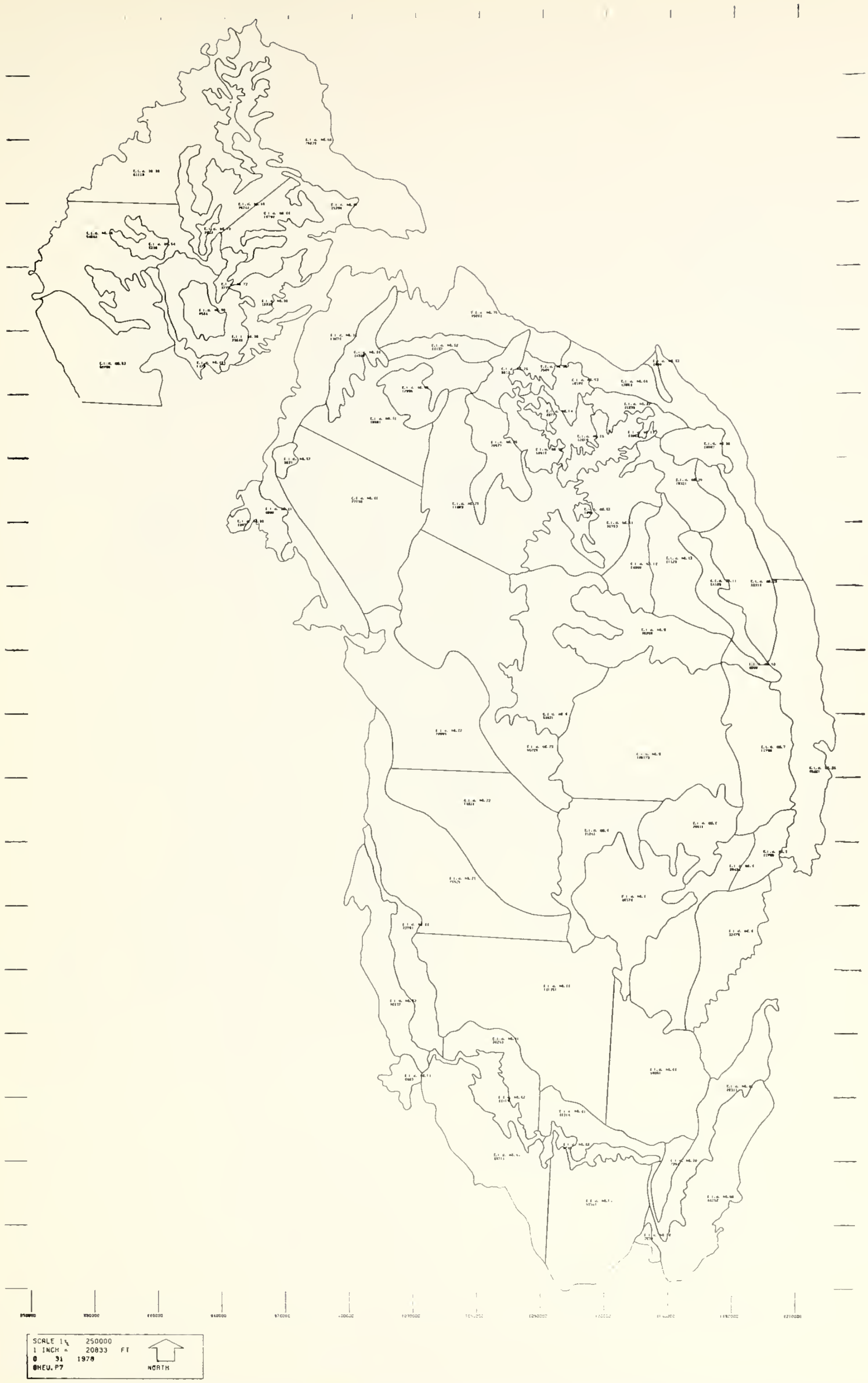

Figure 5. Ecological land unit map of the Black Hills National Forest, South Dakota.

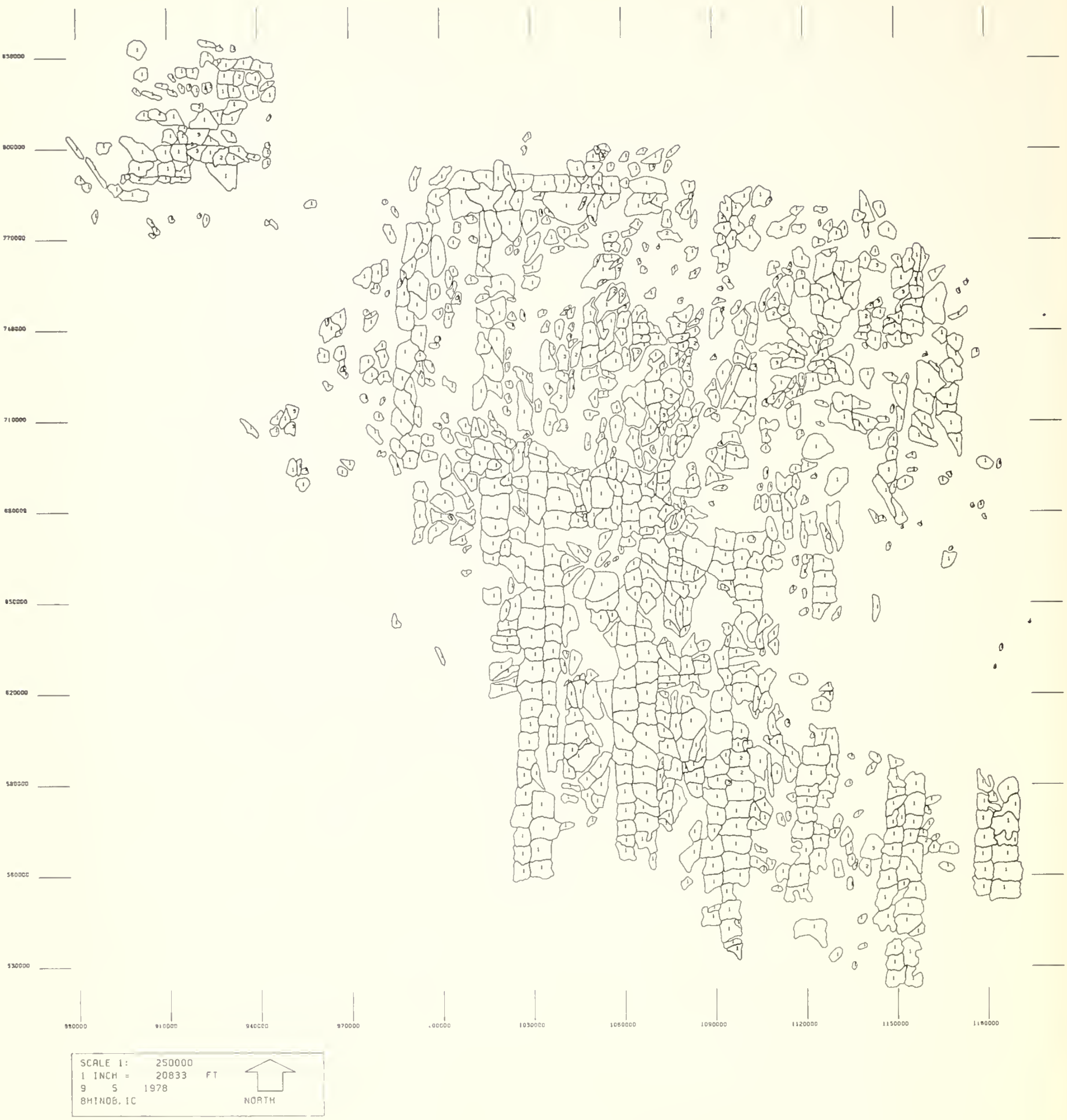

Figure 6. Mountain pine beetle infestation status of the Black Hills National Forest, South Dakota, during 1977.

Figure 7. Map of mountain pine beetle infestation status over ELU's boundaries, Black Hills National Forest, South Dakota, during 1977.

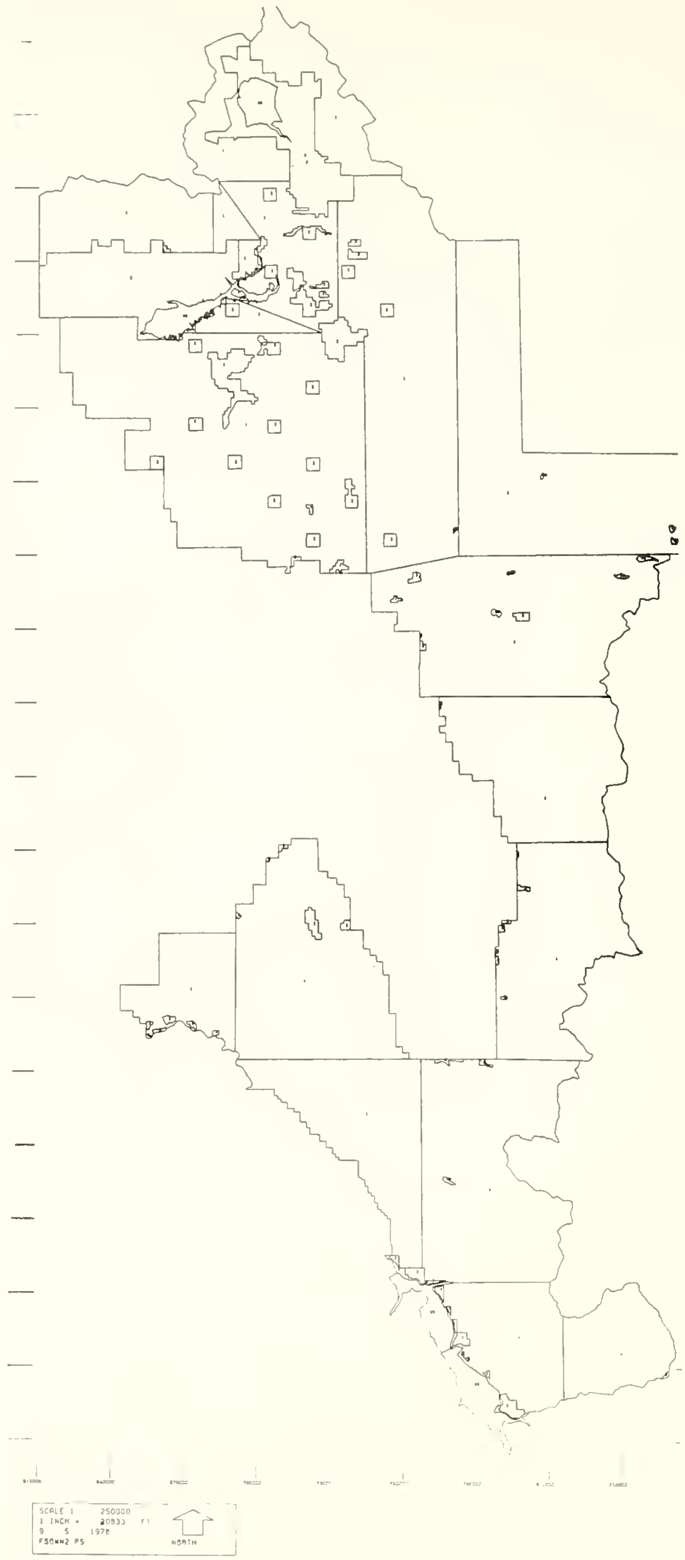

Figure 8. Ownership class map of the Targhee National Forest, Idaho.

Figure 9. Mountain pine beetle infestation status on the Targhee National Forest, Idaho, during 1976.

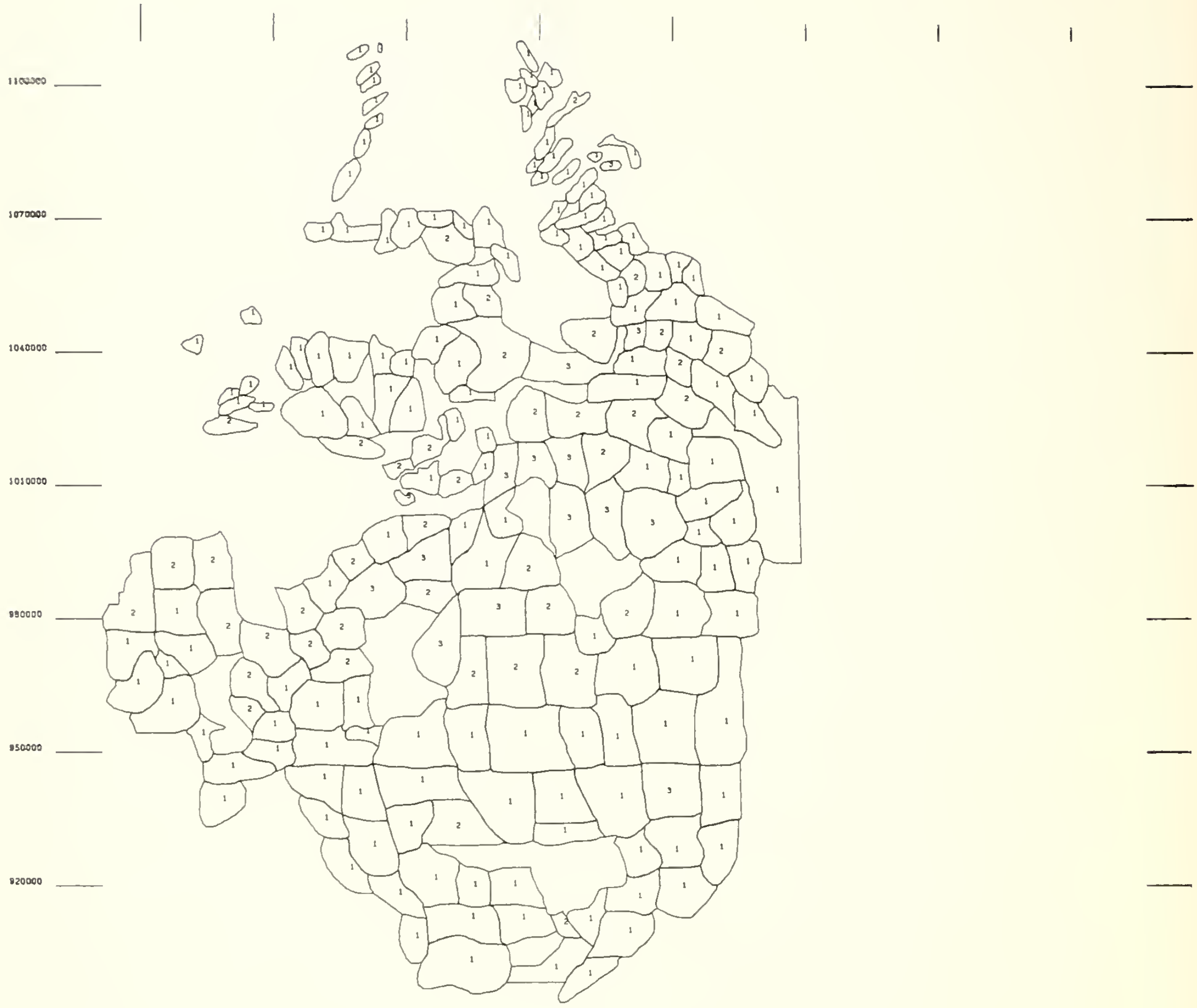

Figure 10. Mountain pine beetle infestation status on the Targhee National Forest, Idaho, during 1977.

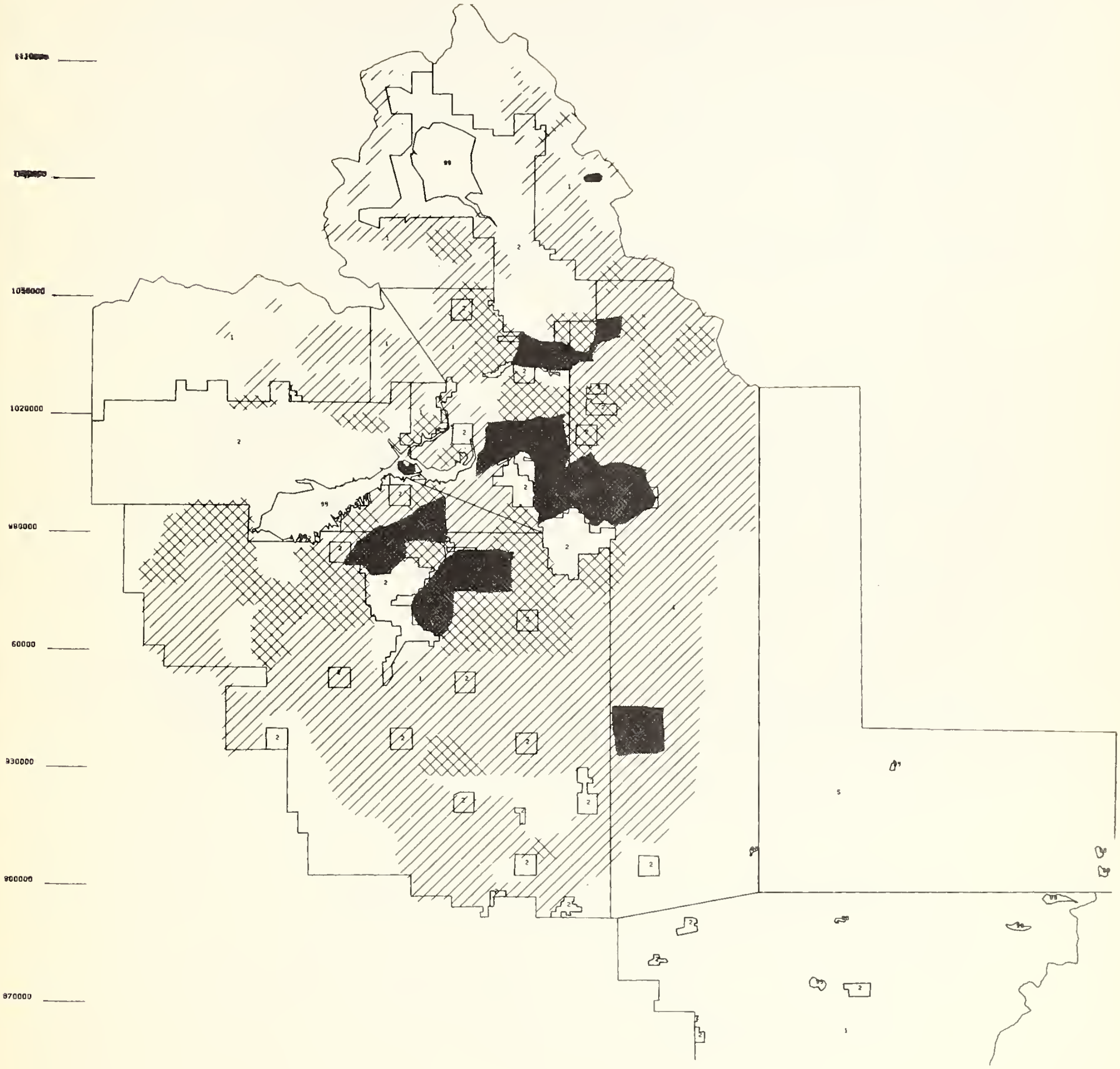

Figure 11. Mountain pine beetle infestation status over ownership class, Targhee National Forest, 1977.

Time and Cost

Two separate purchase orders were submitted to COMARC Design Systems in April 1978 for the Black Hills and Targhee National Forests projects. Digitizing began shortly thereafter. Final products were delivered in August 1978. Since time was not critical, COMARC scheduled the work between other projects extending the total completion time. Under operational time constraints, a project of this magnitude, six map sources and four map overlays could be accomplished in three weeks.

The demonstration project cost $4,000 for the Black Hills and $3,000 for the Targhee. These charges included all the steps outlined in Figure 1. Certain one-time charges were incurred, including processing two ownership maps, processing the ELU maps for the Black Hills, and special programming to convert the polygons on the bark beetle maps into intensity classes. Base maps and special programs are now available for future use. Since the project was limited in scope, the costs are not representative of a full-scale operational project.

A better estimate for a large-scale operational time and costs can be obtained from a project being undertaken in the Southern Region of USDA-Forest Service. Two National Forests in North Carolina, the Nantahala and Pisgah, are utilizing a geographic data base system (L.R.I.S., Raleigh, North Carolina[3]) (USDA Forest Service 1979) for developing a Forest plan under provisions of Section 6 of the National Forest Management Act. The management plan will utilize more than 25 layers of resource data. Digitizing will be done under contract with North Carolina State University, while data processing will be done under contract with L.R.I.S.. Project will run for three years.

CONCLUSIONS

Results of the demonstration indicated that at least one commercially available geographic data base system exists that satisfies FI&DM requirements for analysis, storage, retrieval, and display of data on major forest pests. The system is capable of:

1. Providing an accurate land ownership class base.

2. Summarizing insect infestations of several intensity classes by ownership class or ecological land unit.

Other potential applications include:

1. Comparison of insect infestation boundaries for several successive years.

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[3] L.R.I.S. is the Land Resource Information System, North Carolina Department of Natural Resources, Raleigh, North Carolina. L.R.I.S. geographic data base system is a COMARC system.

2. Integration of insect and disease status maps with other layers of resource information such as vegetation types, soil types, access, or typographic data.

3. Aggregation of insect and disease information for statewide summaries.

Map outputs of the COMARC system are easy to interpret because the arc mode inputs eliminate the "double trace" phenomenon inherent in polygon mapping systems evaluated to date (Young 1977).

Tabular outputs are user-oriented, easily understood, and can be readily transferred to tabular summaries in insect and disease status reports published by FI&DM.

COMARC's geographic data base system or similar systems would meet requirements of the Forest Insect and Disease Information System (FIDIS) designed to store and display information on major forest insect and disease pests where both tabular and graphic outputs are desired.

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APPENDIX

The information in this section pertains to technical aspects of COMARC's geographic data base system, including hardware, software, and concepts of project management. The information is provided for the purpose of describing an existing operational system.

Hardware Description

COMARC's hardware configuration (Figs. 1 and 2) is a complete system by itself. That is, the equipment is sufficient to:

1. Capture data via on-line digitizing, keyboard entry or reading pre-digitized magnetic tape data.

2. Handle storage functions and process necessary transformations and analyses of the data.

3. Plot and print the required output.

The central processing unit is a Data General Eclipse S230 with hardware floating point and up to 512 K of memory.

This computer has demonstrated FORTRAN processing speeds comparable to an IBM 370/158. Because of this computer's large capacity, speed, and expandability, and the sophisticated Real Time Disc Operating System and Advanced Operating System, there should be no need to use a host computer. The S230 can, however, be easily interfaced with other systems to facilitate transfer of data and backup if needed.

For on-line storage there is a 96 million character removable disc subsystem which is field-expandable to 190 million characters. As many as 16 such discs can be included in the system. For off-line storage, backup, and maintenance purposes there are 7- or 9-track, 800 or 1600 bpi, 75 inches per second tape drives.

The system also accommodates various terminals: the Data General video or hard copy terminal, and the full line of Tektronix graphic terminals. To enable hard copy reports or listings to be generated from either terminal, a full-width 300 or 600 lpm line printer is included.

For encoding data, a Talos 660B digitizer with a 44" x 60" active work surface and a free-moving, absolute cursor is plugged into one of the partitions. Because the Tektronix is plugged into this same partition, attribute data relating to the digitizing can be entered at the same time. Up to 16 of these stations can be run off the single CPU.

Finally, a Zeta or Calcomp pen plotter and/or Versatec electrostatic plotter is included for hard copy graphics.

This configuration provides a complete system with capability, flexibility, and expandability. There can be up to 64 people processing

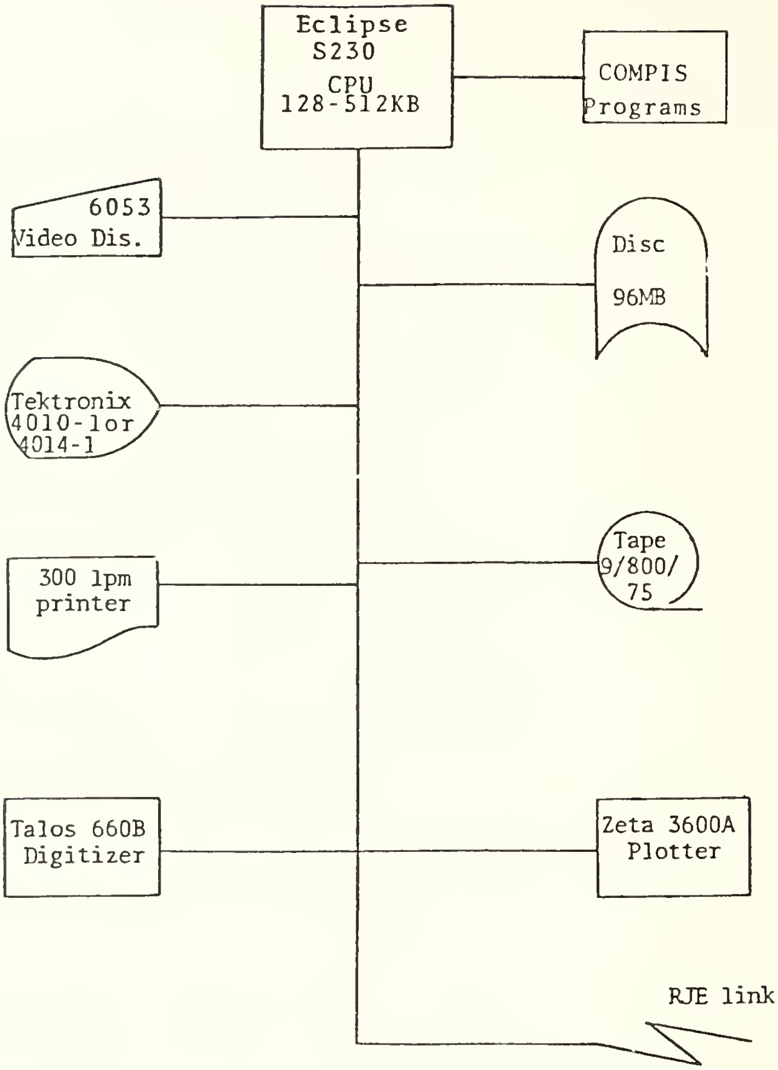

Figure 1. STANDARD COMARC SYSTEM CONFIGURATION

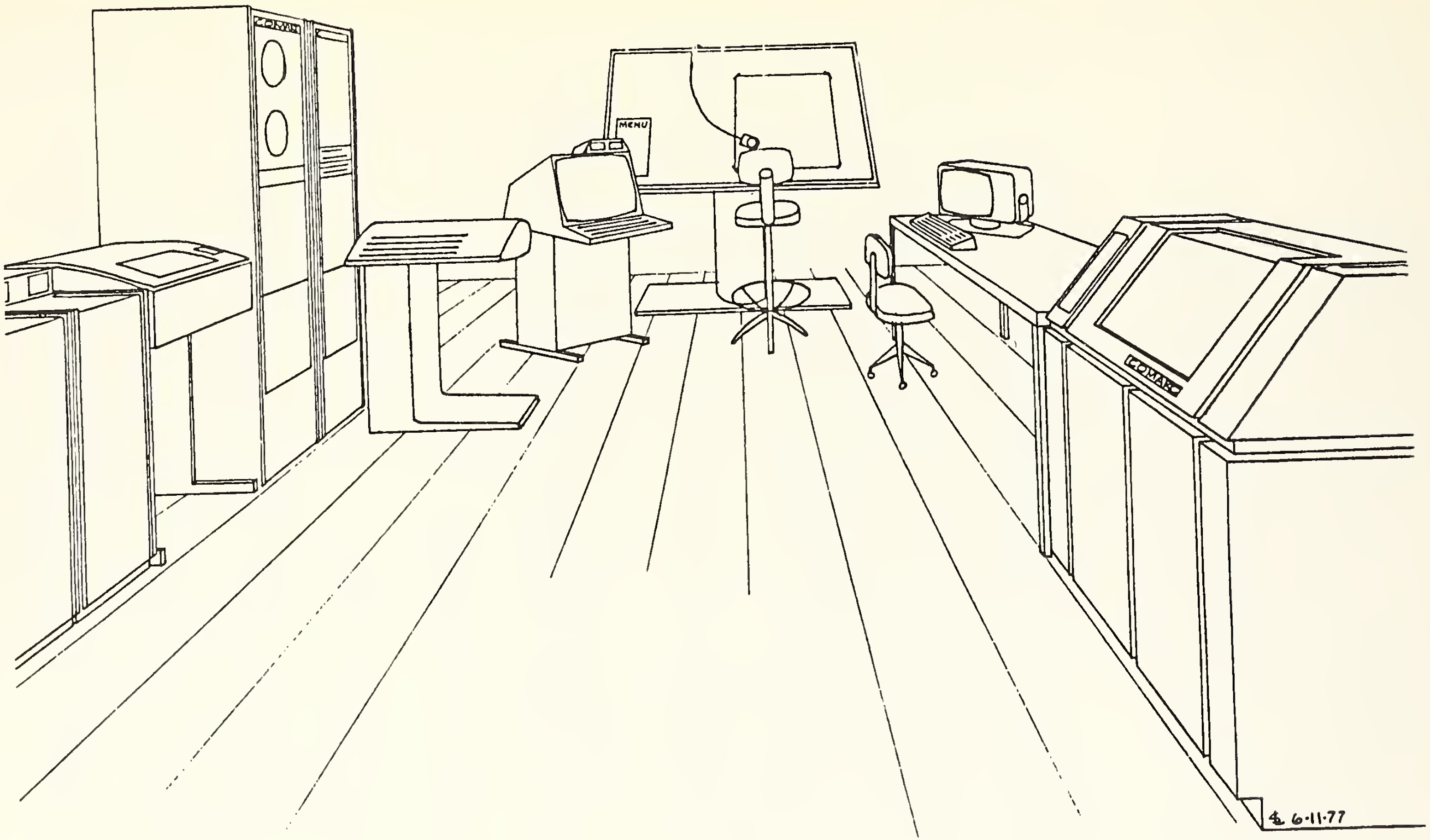

Figure 2. Standard COMARC system physical layout

or digtizing at the same time and the plotter can be operating simultaneously in the background. With the RJE interface and a telephone company-supplied model, the system can talk to COMARC's computer to transfer new programs or help solve problems. And because of the system's tremendous expandability it is unlikely that the user will ever outgrow the system.

Program Capabilities

Following is a brief description of the sustained program routines contained in COMARC's geo-based information system. Many additional non-standard capabilities have been developed and are also available.

Digitizing

Whole Polygons: Areal data can be digitized on whole polygons in stream or point mode. As many as 4,000 points may be stored to define any one polygon. System will automatically discover, correct, and report such common digitizing errors as non-closure and digitizing past the start point.

Arcs: Areal data can be digitized in stream or point mode as arcs (segments) to eliminate double line digitizing. The system will assemble the unannotated arcs into whole polygons and utilize digitized label centroids to automatically assign labels to each arc or assembled polygon.

Lines: Linear features such as roads and streams can be digitized in point or stream mode.

Contours: Topography or isolines can be digitized in point or stream mode. Peak tops and other point elevations can also be digitized and utilized by the system in conjunction with the contours to provide an accurate topographic representation.

Points: Data located with a point can be digitized and stored in that form.

Scaling and Coordinate Conversion

Scaling Input: Multiple scaling points can be input to enable the system to remove scaling distortion by fitting the digitized map to known control points using rubber-sheeting techniques.

Scaling Output: Map can be output at any scale regardless of input scale. When the map scale selected results in a map too large for the plotter, it can be segmented and output as separate sheets.

Coordinate Conversions: Data can be converted from UTM to latitude/longitude, State Plane to latitude/longitude, or vice versa.

Data Manipulation and Display

The COMPIS interactive system is a conversational, user-friendly program which controls some 120 subprograms handling analysis and digitizing capabilities. COMPIS is structured to simplify the use of the system and make the complexities of program selection and file handling transparent to the user. For ease of use, the COMPIS driver directs the user into one of four groups of programs under the headings of Polygons, Grids, Topography, Lines. The standard functions offered within these four program groupings follow.

Polygons

These programs function on data digitized as whole polygons, on polygons created from digitized arcs, and on polygons created from grids (including Landsat pixels read into the system from computer-compatible tapes).

Polygon File Report: Produces a report on the line printer listing the sequence number, label code, label name, X/Y centroid, number of coordinates and acres for each polygon in a file.

Acre Summary: Produces a report summarizing by label code the acreage and number of polygons of each data type in a file.

Change Map Parameters: Enables the user to change any parameter. At the beginning of each file and report are 16 map parameters providing information such as client number, project number, map number, scale of data map, etc..

Edit Files: Provides the user with the capability to perform non-graphic keyboard edits such as deleting a polygon, changing labels, thinning selectively, and incorporating a digitized edit file.

Thin: Utilizes a mathematical algorithm to reduce the number of points in each polygon to a specified maximum, or to thin each polygon using a specified delta factor.

Merge: Merges adjoining maps or merges data from separate layers into one group.

Extract: Allows the user to specify certain parameters such as a window, label code, and/or minimum and maximum size as the basis for selecting polygons from one file and creating a new file.

Label Functions: Creates a table of label names which can be incorporated into a polygon file to provide names for label codes. This option also enables the user to create new labels for use in overlayed files where each resultant polygon represents two or more layers of data.

Donut Hole Program: Automatically discovers donut holes (islands) and restructures the file so that correct acreage calculations will result in both single layer and overlayed files.

Polygon Overlay: Overlays any two polygon layers using an intersection technique (not micro-cells). New polygons and label centroids will be created wherever polygons from the two layers overlap.

Window Overlay: Creates a polygon to fit the coordinates specified by the user and then overlays that polygon on any other layer of data. This is used to accurately segment a file.

Replacement Overlay: Takes polygons from one layer and inserts them in another layer, eliminating all data from the second layer which is coincident with the polygons from the first layer. An example of this would be to overlay a map containing harvest boundaries on a map showing forest cover to produce a revised cover map showing all cover removed in the harvest areas.

Convert to Grids: Enables the user to convert any polygon file into a grid file with any size of grid.

Tektronix Graphics Program: Utilizes the Textronix graphics capabilities and provides the user with several options including displaying data at any scale, zooming, graphic overlays of several layers, plotting selected polygons, graphic editing using the CRT cursor, etc..

Plot Program: Sets up a plot file for a pen plotter. This enables the user to select any output scale, information to be plotted in each polygon, label size, minimum polygon size, etc.. The program automatically creates a title block with information such as map name, date, north arrow, scale, and adds borders and tick marks to the map.

Grids

Acre Summary: Produces a report on the line printer summarizing the acres and percent of site occupied by each data category.

Edit: Changes the assignment of any cell.

Segment: Produces a reduced study area or separate sheets for plotting.

Translation: Translates an interpreted map from a source map, e.g., interpreting erosion from soils.

Pairwise: Interprets a new map or file from two source files, e.g., slope stability being interpreted from slope and geology.

Proximity: Enables the user to produce a map showing the distance of each cell from a designated point or linear feature, e.g., distance to roads, towns, etc..

Overlay: Overlays as many as 20 grid maps to produce a composite map. The layers of data can be given different weights if the user desires.

Extreme Value Search: Overlays as many as 20 maps to determine the most extreme value in each cell.

Convert Grids to Polygons: Converts any grid file to a polygon file compatible with the COMARC polygon routines and other polygon files.

Cell Inventory Report: Produces a report summarizing all layers of data for each cell.

Line Printer Map: Outputs any grid map on the line printer, scaled or unscaled, shaded or unshaded.

Plot Program: Sets up a plot file for a pen plotter. This enables the user to select any output scale and label size. The program automatically creates a title block with information such a map name, date, north arrow, and scale and adds borders to the map.

Topography

Edit: Enables the user to alter the elevation of any point in the file.

Segment: Enables the user to segment the file to create a smaller study area or separate output maps.

Elevation Report: Produces a grid map on the line printer with the elevation printed at each point on the grid.

Slope: Utilizes a vector analysis to calculate the percent slope for each area of the site. It then ranges it into any slope classes selected by the user.

Aspect: Calculates the direction of slope for each area of the site and ranges it into directional, sun exposure, or wind exposure ranges as specified by the user.

View: Calculates the visibility of any site or proposed facility or the viewshed from any point or linear feature such as a road.

Grid Percentage: Calculates and displays perspectives of a site from any observation point with the surface being represented as a warped grid. Hidden lines are removed and the vertical scale may be emphasized.

Shaded Perspective: Calculates and displays a perspective of a site from any observation point with the surface being represented by a series of cross sections plotted perpendicular to the observation point. Hidden lines are removed and the vertical scale may be emphasized.

Map Perspective: Plots any mapped information such as land use, soils, zoning, or suitability on the surface of a shaded or grid perspective.

Drainage: Calculates and plots the drainage pattern on a site.

Cross Section: Plots a cross section at any scale between any two points on a site.

Contour Map: Produces a contour map with any contour interval regardless of the interval originally digitized.

Cut/Fill Calculations: Calculates cubic yards or meters of earthwork using two digitized layers of data, one representing the site before grading and the other after grading. In addition to listing total volume of cut and fill, these calculations will produce a map on the line printer showing the elevation at each point on the site before and after grading, and the volume of cut or fill in that area of the site.

Cut/Fill Distribution: Utilizes the results of the cut/fill calculations to produce a map on the plotter at any scale showing areas and volumes of cut and fill.

Land Disturbance: Produces an isoline map at any scale showing depths of cut and fill.

Lines and Points

Lines are linear features such as roads and streams. Where appropriate, the following routines also function with point files.

Edit: Enables the user to delete lines, change labels, and modify alignments.

Segment: Reduces the size of the study area or creates separate files for plotting.

Merge: Merges adjoining maps or merges two or more layers of data into one map.

Thin: Uses a mathematical algorithm to reduce the number of points in each line to a specific maximum or to thin each polygon using a specified delta factor.

Length Summary: Produces a report on the line printer listing the label code, label name, number of points, and length of each line in a file.

Extract: Allows the user to specify certain parameters such as a windlow label code and/or minimum and maximum length as the basis for selecting lines from one file and creating a new file.

Label Function: Creates a table of label of label names which can be incorporated into a polygon file to provide names for label codes.

Convert to Grids: Converts any line or point file into a grid file with any size of grid.

Tektronix Graphics Program: Utilizes the Tektronix graphics capabilities and provides the user with several options, including digitizing data on the CRT at any scale, zooming, graphic overlays, plotting selected lines or points, graphic editing using the CRT cursor, etc..

Plot Program: Sets up a plot file for a pen plotter. This enables the user to select any output scale, information to be plotted by each polygon, label size, etc.. The program automatically creates a title block with information such as map name, date, north arrow and scale, and adds border and tick marks to the map.

Project Management

The successful application of a computer mapping system is realized when the final products are effectively used in a decision making framework. The following concepts reflect how this can be achieved:

1. Recognize that the system is not the final product.

2. Recognize the difference between computer graphics and a geographically-based information system.

3. Recognize that an important component of an application system is people.

4. Recognize that the system must be readily understood and operated by potential users, not computer specialists.

Knowing how to properly use a geographic data system is as important as having access to a good one. Following are seven basic rules which are important in the successful application of a system.

1. Organize projects in advance. This will eliminate cluttering the data base with unneeded information and avoid dead ends where the data does not satisfactorily address the issues.

2. <u>Design your projects to take full advantage of the system</u>. The system should serve as the framework of the project, thereby creating new approaches and offering new opportunities. To the extent this system is viewed simply as a faster way to carry out work in the existing manner, its power will be severly limited.

3. <u>Don't try to make the system do everything</u>. Recognize that with the available technology, some tasks can be most efficiently performed by the system while others are best done manually. Don't fall into the trap of thinking that if the system is to be used at all, it must completely replace manual labor.

4. <u>The data base is not the final product</u>. Constantly be thinking about how the base is going to be used, not just how comprehensive it will be. The purpose of the data base will not be realized until it is being utilized to solve problems.

5. <u>Recognize the need to proceed with the best available data</u>. It is generally not possible within time and cost constraints to produce a "perfect" data base for use on a project. The fact that the data is not perfect should not exclude the use of the system any more than it precludes the execution of the project with manual techniques. The system will provide the consistency, accuracy, and flexibility necessary to ensure that the user gets the most out of whatever data is available.

   The criterium for judging a data base should not, therefore, be "Is it perfect?" Rather, it should be asked, "Is the final product of the project better because the system was used?"

6. <u>Carefully document the use of the system</u>. Once data is in the system, it can be plotted out at any scale with what can be deceptively fine resolution. This can give the user false confidence in the data base. Ensure that all data sources and manipulative criteria are carefully documented and referred to by the user.

7. <u>Produce easy to use reports and graphics</u>. Remember that most people reviewing the results of a project have no knowledge or interest in computers or mapping. The output should therefore be in a form which clearly communicates what needs to be said, without the user "learning" the format.

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